

National Aeronautics and Space Administration



Astrophysics

Paul Hertz

Doris Daou

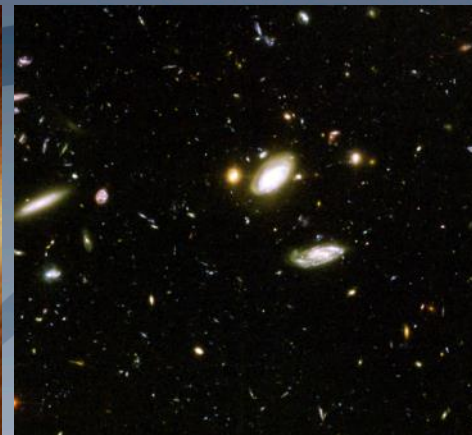
Douglas Hudgins

Christina Richey

Daniel Evans

Mario Perez

Martin Still



NASA Townhall Meeting

AAS 228th Meeting
San Diego, California
June 12-16, 2016

Paul Hertz

Director, Astrophysics Division
Science Mission Directorate

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www.nasa.gov

This presentation is posted at
<http://science.nasa.gov/astrophysics/documents/>

SMD Leadership Change

- John Grunsfeld has retired from NASA as of May 31.
- Geoffrey Yoder, previously the Deputy Associate Administrator for SMD, is now the Acting Associate Administrator for SMD.



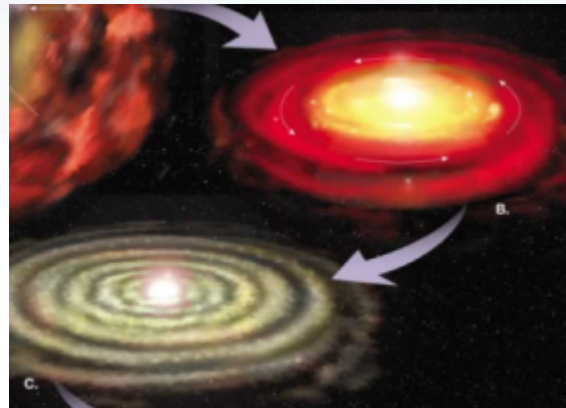
- Mr. Yoder has spent 16 years in industry and 16 years at NASA, and his prior assignments include Deputy Director for Astrophysics, Acting Director for Astrophysics, JWST Program Director, SMD Deputy AA for Programs, and SMD Deputy AA.
- Mr. Yoder's priorities for SMD are
 - Continuing to advance the SMD missions in formulation, development, and operations.
 - Integrating strategic planning across all Divisions to further advance NASA objectives and Decadal Surveys.
 - Making NASA's technical and capability management more efficient to free up resources for missions and science.
 - Basing NASA's decisions firmly on community input and peer review.

Why Astrophysics?

Astrophysics is humankind's scientific endeavor to understand the universe and our place in it.



1. How did our universe begin and evolve?

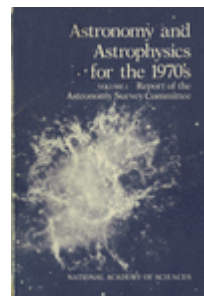


2. How did galaxies, stars, and planets come to be?

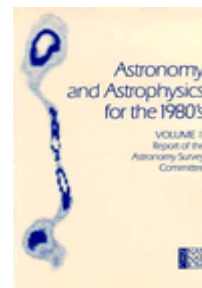


3. Are We Alone?

These national strategic drivers are enduring



1972



1982



1991

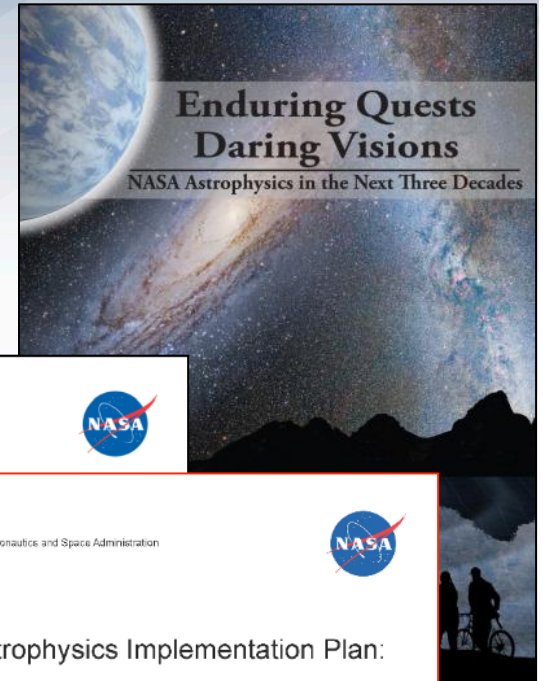
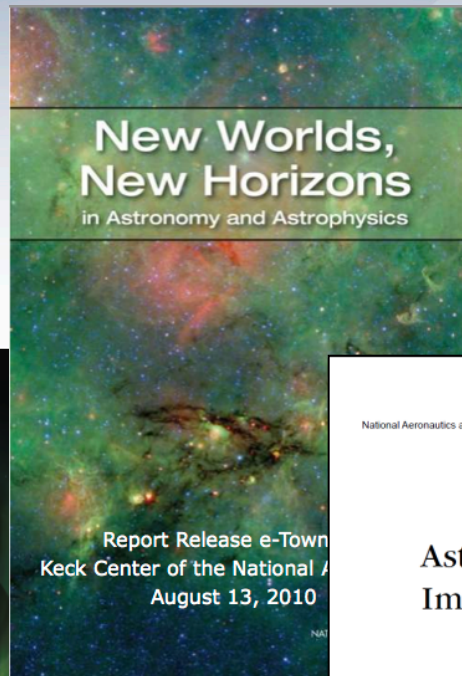
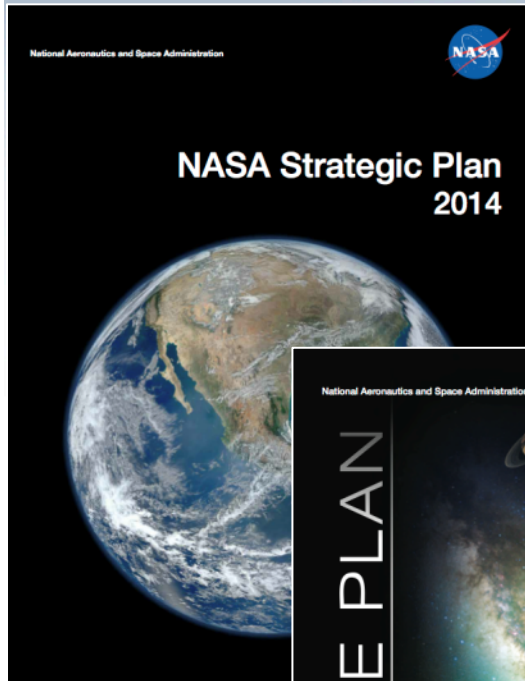


2001



2010

Astrophysics Driving Documents



Next update: December 2016

Will include:

- Response to Mid-Term Report
- Planning for 2020 Decadal Survey



<http://science.nasa.gov/astrophysics/documents>

NASA Astrophysics Activities

Strategic Missions

Hubble Space Telescope, Chandra X-ray Observatory, XMM-Newton (ESA mission), Spitzer Space Telescope, Fermi Gamma-ray Space Telescope, Kepler Space Telescope, Stratospheric Observatory for Infrared Astronomy (SOFIA), LISA Pathfinder (ESA mission), James Webb Space Telescope, Widefield Infrared Survey Telescope (WFIRST)

Explorers Missions

Swift Gamma-ray Burst Explorer, Nuclear Spectroscopic Telescope Array (NuSTAR), Neutron star Interior Composition Explorer (NICER), Transiting Exoplanet Survey Satellite (TESS), SMEX (AO 2014): IXPE, PRAXYS, or SPHEREX, MO (AO 2014): LiteBIRD (JAXA mission) or GUSTO, MINDEX/MO AO in 2016

Research and Analysis

Astrophysics Data Analysis Program (ADAP), Astrophysics Research and Analysis (APRA), Astrophysics Theory Program (ATP), Einstein Fellowships, Exoplanet Research Program (XRP), Hubble Fellowships, Roman Technology Fellowships (RTF), Sagan Fellowships, Theoretical and Computational Astrophysics Networks (TCAN)

Other Activities

Astrophysics Archives (ADS, HEASARC, IRSA, MAST, NED, NExSci), Balloon Program, Cosmic-ray Energy and Mass on the International Space Station (ISS-CREAM), Keck Observatory, Large Binocular Telescope Interferometer (LBTI), NASA-NSF Exoplanet Observational Research (NN-EXPLORE)

SMD STEM Education Activities

NASA Astrophysics Community Groups

- **Federal Advisory Committees**
 - Committee on Astronomy and Astrophysics (NRC Space Studies Board)
 - Astronomy and Astrophysics Advisory Committee (NSF/NASA/DOE)
 - Astrophysics Subcommittee (NASA Advisory Council)
- **Program Analysis Groups**
 - Cosmic Origins Program Analysis Group – COPAG
 - Exoplanet Exploration Program Analysis Group – ExoPAG
 - Physics of the Cosmos Program Analysis Group – PhysPAG
- **Operating Mission Users Groups (examples)**
 - Hubble Space Telescope Users Committee
 - Chandra Users Committee
 - Spitzer Science Users Panel
 - SOFIA Users Group
- **Science and Technology Definition Teams**
 - Far Infrared Surveyor
 - Habitable Exoplanet Imaging Mission
 - Large UV/Optical/IR Surveyor
 - X-ray Surveyor
- To get involved with a mission users group, contact the Center Project Scientist or Users Group Chair for any mission.
- To volunteer for a Federal Advisory Committee or a Program Analysis Group, sign up for the Astrophysics NSPIRES email list and respond to our annual call for self-nominations.

Astrophysics - Big Picture

- **The FY16 appropriation and FY17 President's budget request provide funding for NASA astrophysics to continue its programs, missions, projects, and supporting research and technology.**
 - The total funding (Astrophysics including Webb excluding STEM) remains at ~\$1.35B.
 - Fully funds Webb to remain on plan for an October 2018 launch.
 - Funds WFIRST formulation (new start) starting in February 2016.
 - Allows operating missions to continue in FY16 and through FY18 (2016 Senior Review).
 - Funds SMD STEM education activities across astrophysics and other disciplines.
- **The operating missions continue to generate important and compelling science results, and new missions are under development for the future.**
 - Chandra, Fermi, Hubble, Kepler/K2, NuSTAR, Spitzer, Swift, ESA's XMM-Newton all operating well; Senior Review in Spring 2016 recommended continued operation.
 - SOFIA is in 5-year prime operations as of May 2014; HAWC+ 2nd generation instrument commissioning in Spring 2016; 3rd generation instrument studies underway.
 - ESA's LISA Pathfinder successfully launched on December 3, 2015; performing well.
 - JAXA's Hitomi (née ASTRO-H) launched on February 17, 2016; communication was lost with spacecraft on March 26, 2016, and JAXA has ceased recovery efforts.
 - Missions under development for launch include NICER (2017), ISS-CREAM (2017), TESS (2017), Webb (2018), ESA's Euclid (2020), WFIRST (mid-2020s).
 - 5 SMEX and MO concept studies selected in 2015; MIDEX AO in 2016; NASA joining ESA's Athena X-ray observatory (2028) and ESA's L3 gravitational wave obs (2034).
- **Progress being made toward recommendations of the 2010 Decadal Survey.**
 - NRC Mid Decade Review (with NSF, DOE) underway; report expected in Jun/Jul 2016.
 - NASA initiating large and medium mission concept studies as input for 2020 Decadal Survey.



NASA Astrophysics

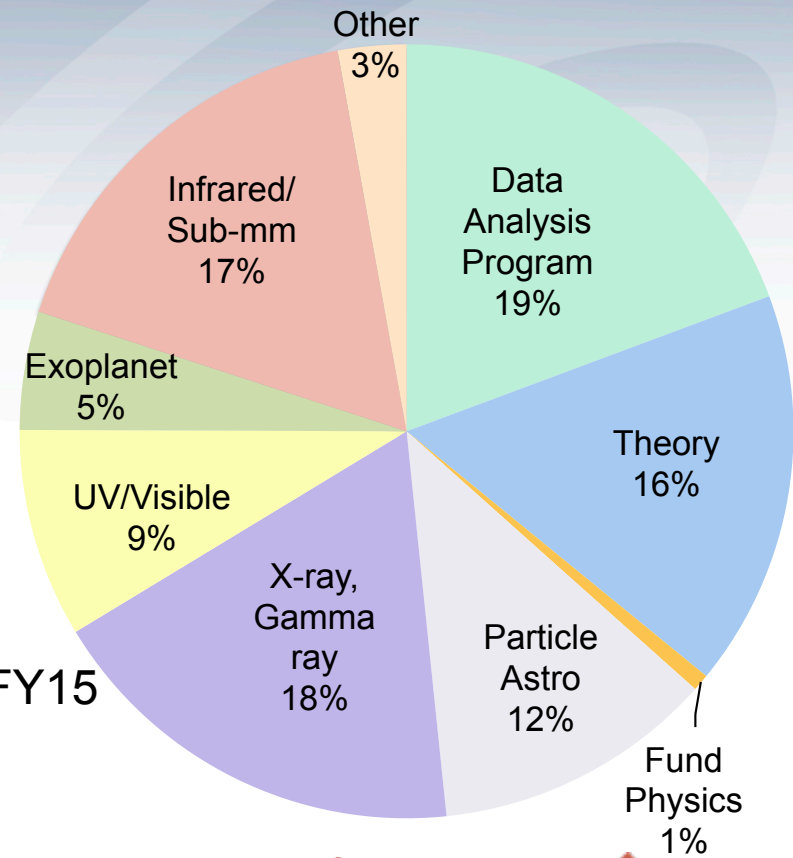
Program Update

- Research and analysis
- Missions in extended operation
- Missions in prime operation
- Suborbital missions
- Missions in development

Astrophysics Research Program Funding

Most recent year:

	Proposals		Success	Year-1
	Rec'd	selected	Rate	\$M
RTF-15	5	3	60%	0.3
APRA-14	149	42	28%	12.7
SAT-14	27	11	41%	6.6
ADAP-15	249	51	20%	6.2
XRP-15	43	7	16%	1.2
ATP-14	214	32	15%	4.7



Split of \$88M in FY15



Recent Proposal Selections

Status: May 18, 2016

	Proposal Due Date	Notify Date	Days past received	Number received	Number selected	% selected
Chandra GO – Cycle 17	Mar 17, 2015	July 17, 2015	122	582	175	30%
APRA (Basic Research)	Mar 20, 2015	Aug 12, 2015	145	149	40	27%
SAT (Technology)	Mar 20, 2015	Aug 12, 2015	145	27	11	41%
Hubble GO – Cycle 23	Apr 10, 2015	June 24, 2015	75	1114	261	23%
EPDS (Doppler Spectr)	Apr 24, 2015	July 2, 2015	69	6	2	33%
ADAP (Data Analysis)	May 15, 2015	Sep 29, 2015	137	250	51	20%
Exoplanet Research	May 22, 2015	Oct 15, 2015	146	43	7	16%
Kepler K2 GO – Cycle 3	Jul 1, 2015	Oct 14, 2015	105	72	32	44%
SOFIA GI – Cycle 4	Jul 10, 2015	Oct 22, 2015	104	155	82	53%
Spitzer GO – Cycle 12	Sep 11, 2015	Oct 26, 2015	45	104	31	30%
SOFIA 3 rd Gen Instrument	Oct 7, 2015	Dec 10, 2015	64	3	2	67%
WFIRST Sci. Inv. Teams	Oct 15, 2015	Dec 18, 2015	64	38	13	34%
Swift GI – Cycle 12	Sep 25, 2015	Jan 19, 2016	116	185	43	23%
Roman Tech Fellows	Nov 6, 2015	Feb 5, 2016	91	5	3	60%
NuSTAR GO – Cycle 2	Dec 11, 2015	Feb 2, 2016	53	185	50	27%
Fermi GI – Cycle 9	Jan 22, 2016	May 5, 2016	104	185	Pending SR	Pending SR
NESSF-16	Feb 8, 2016					
Kepler K2 GO – Cycle 4	Mar 4, 2016					
Chandra GO – Cycle 18	Mar 15, 2016					
APRA (Basic Research)	Mar 18, 2016					
SAT (Technology)	Mar 18, 2016					
Hubble GO – Cycle 24	Apr 8, 2016					
ADAP (Data Analysis)	May 13, 2015					
Exoplanet Research	May 23, 2015					
Spitzer GO – Cycle 13	June 8, 2016					

**100% of 2015-16 selections
announced within 150 days**

**R&A Selection Rate: 23%
GO Selection Rate: 28%**

Proposal Opportunities Expected in 2016-2017

July 1, 2016	SOFIA GO Cycle 5	www.sofia.usra.edu
July 8, 2016	Astrophysics Theory	ROSES-16 D.4
September 23, 2016	Swift GI Cycle 13	ROSES-16 D.5
September 23, 2016	Kepler K2 GO Cycle 5 (Step 1)	ROSES-16 D.7
Fall 2016	Explorers MDEX & MO AO	NSPIRES
October 2016	XMM-Newton GO Cycle 16	heasarc.gsfc.nasa.gov
November 18, 2016	Habitable Worlds (Step 1)	ROSES-16 E.4
January 13, 2017	NuSTAR GO Cycle 3	ROSES-16 D.10
January 20, 2017	Fermi GI Cycle 10	ROSES-16 D.6
March 17, 2017	Astrophysics R&A	ROSES-16 D.3
March 17, 2017	Strategic Astrophysics Technology	ROSES-16 D.8
March 2017	Exoplanet Research (Step 1)	ROSES-17
March 2017	Chandra GO Cycle 19	cxc.harvard.edu
April 2017	Hubble Cycle 24	www.stsci.edu
May 2017	Astrophysics Data Analysis	ROSES-17
June 2017	Spitzer GO Cycle 14	ssc.spitzer.caltech.edu
Late 2017	Webb GO Cycle 1	TBD

Explorers MINDEX and MO AO in 2016

- Target dates: draft AO late Spring 2016, AO release late Summer 2016, proposals due 90 days later, Selection Summer 2017, final downselect late 2018.
- MINDEX: standard launch services on an ELV provided at no charge against the mission cost cap; no MINDEX ISS attached payloads
 - PI-managed Cost Cap for the MINDEX is \$250M (FY2017 dollars)
 - MINDEX launch readiness date no later than December 2023
- MO may be Partner MO, Small Complete Missions (SCM) or NMES.
 - SCM that are suborbital class (ULDB, CubeSat, SRLV) or on ISS: access to space provided by NASA at no charge to PI-managed Mission Cost
 - PI-managed Cost Cap for the MO is \$70M, \$35M for suborbital class MO
 - SCM launch readiness date no later than December 2022
 - PMO or NMES endorsement need date before January 2022
- Selected missions execute a nine-month Phase A study funded at \$2M for MINDEX, \$500K for MO
 - Science Enhancement Options (SEOs) are allowed
 - Student Collaborations are allowed (incentive of 1% of the PI-Managed Mission Cost Cap)
 - NASA-developed technology infusion may be allowed



2016 Astrophysics Senior Review

Chandra X-ray
Observatory Panel

Hubble Space Telescope
Panel

Budgets already recognized in the notional run-out of the President's FY 2016 budget request. Mature and stable missions with no operational changes.

Main Panel:

Fermi
Kepler/K2
NuSTAR
Spitzer
Swift
XMM-Newton

Main panel.

2016 Astrophysics Senior Review Main Panel Findings – Overall

Mission	Panel Rating	Panel Ranking
Swift	E	1
Kepler/K2	E	2
NuSTAR	E/VG	3
XMM-Newton	E/VG	4
Fermi	E/VG	5
Spitzer	E/VG	6

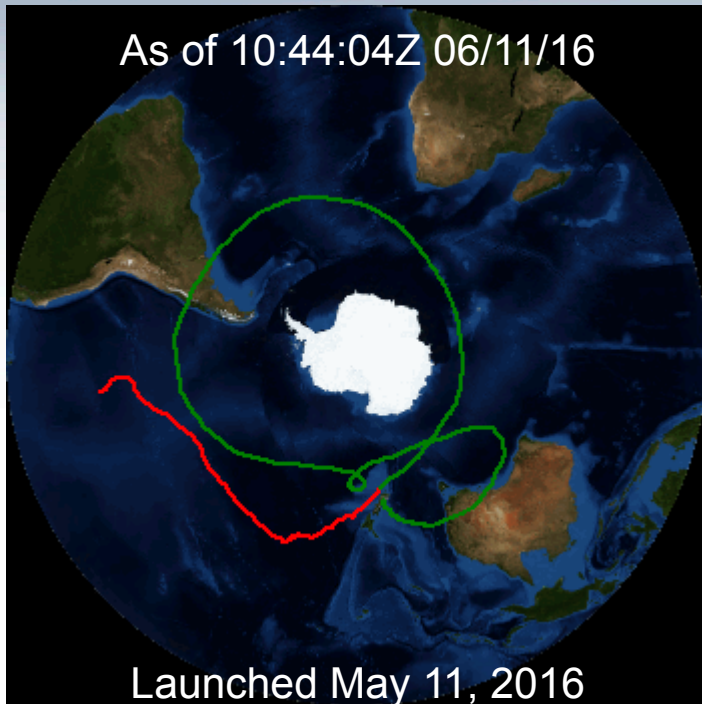
- “The SR2016 panel finds no scientific reason to discontinue or significantly reduce any of the six missions under this review.”
- “We strongly encourage NASA to find a way to continue all of these missions at their full funding level.”
- “The scientific value of the complete Astrophysics Senior Review 2016 portfolio is greater than the sum of its parts.”

2016 Astrophysics Senior Review NASA Implementation Decisions

Mission	Extend?	SR2018?	Comments
Hubble	Yes	Yes	
Chandra	Yes	Yes	
Fermi	Yes	Yes	Reduced budget
Kepler/K2	Yes	No	End-of-mission plan
NuSTAR	Yes	Yes	
Spitzer	Yes	No	Reduced budget; end-of-mission plan
Swift	Yes	Yes	Augmentation for automation
XMM	Yes	Yes	Augmentation for GO program

- Maintain all 8 missions in operation, with K2 and Spitzer ending.
 - Spitzer ending in mid-FY19 after providing significant precursor work for JWST and after JWST commissioned.
 - Kepler/K2 ending in FY19 when fuel is exhausted.
- Maintaining all 8 missions will require some reductions in mission funding in order allow the overarching finding (the continuation of all missions) to be implemented.

2016 New Zealand SPB Campaign

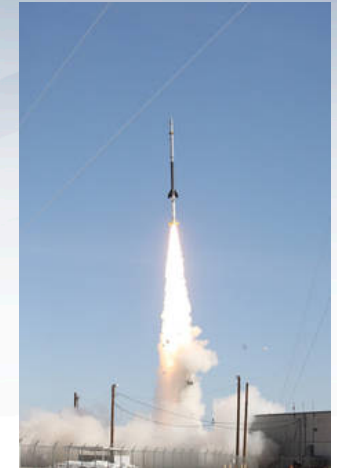


<http://www.csbf.nasa.gov/>
<http://www.csbf.nasa.gov/newzealand/wanaka.htm>

Recent & Upcoming Suborbital Missions

Sounding Rockets

- FY16-FY17 Sounding Rocket Launches @ White Sands NM
 - **PICTURE-B** – S. Chakrabarti, U Mass Lowell (Nov 24, 2015) ✓
 - **DXL** – M. Galeazzi, U Miami (Dec 5, 2015) ✓
 - **FORTIS** – S. McCandliss, JHU (Dec 18, 2015) ✓
 - **CHESS** – K. France, Colorado U (Feb 22, 2016) ✓
 - **Micro-X** – E. Figueroa, MIT (~Nov 2016)
 - **CIBER-2** – J. Bock, Caltech (~Dec 2016)



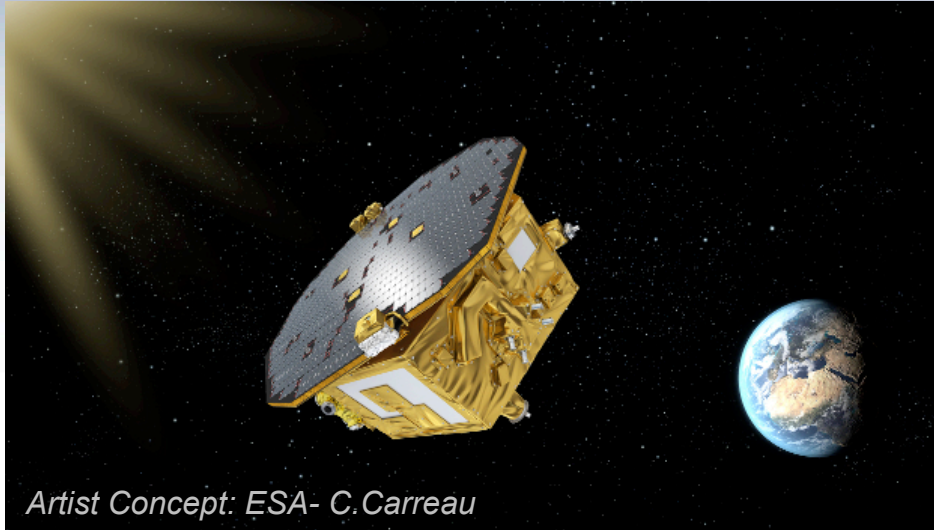
Stratospheric Balloons

- Winter FY16 Conventional Balloon Campaign @ McMurdo Station Antarctica
 - **GRIPS** – P. Saint-Hilaire, UC Berkeley (Jan 19-30, 2016) ✓
- Spring FY16 Super Pressure Balloon Campaign @ Wanaka New Zealand
 - **COSI** – S. Boggs, UC Berkeley (May 16, 2016 **ongoing**) ✓
- Summer FY16 Conventional Balloon Campaign @ Palestine TX
 - **SuperBIT** – W. Jones, Princeton U (Jun 2016 **ready to launch**)
- Fall FY16 Conventional Balloon Campaign @ Ft Sumner NM
 - **BETTII** – S. Rinehart, NASA GSFC (Aug/Sep 2016)
 - **FIREBALL-2** – C. Martin, Caltech (Aug/Sep 2016)
 - **PIPER** – A. Kogut, NASA GSFC (Aug/Sep 2016)
 - **X-Calibur** – H. Krawczynski, Washington U (Aug/Sep 2016)
- Winter FY17 Conventional Balloon Campaign @ McMurdo Station Antarctica
 - **ANITA-4** – P. Gorham, U Hawaii (Dec 2016/Jan 2017)
 - **BACCUS** – E.S. Seo, U Maryland (Dec 2016/Jan 2017)
 - **STO-2** – C. Walker, U Arizona (Dec 2016/Jan 2017)



ST-7/LISA Pathfinder

ST-7/Disturbance Reduction System (DRS)



- ESA Mission with NASA Collaborating
- Project Category: 3 Risk Class: C
- DRS flies on the ESA LISA Pathfinder spacecraft
- Sun-Earth L1 halo orbit
- Drag-free satellite to offset solar pressure
- Payload delivery: July 2009
- Launched: December 3, 2015 GMT
- LPF prime mission: 7 months
- Data Analysis: 12 months

CURRENT STATUS:

- LISA Pathfinder successfully launched on December 3, 2015.
- Satellite reached Earth-Sun L1 on Jan 22 and all systems are nominal.
- Test masses released on Feb 15 ("Elwood") and Feb 16 ("Jake") are operating nominally.
- Began science operations on March 1, 2016.



- ESA's LISA Test Package for 90 days
- LISA test package performance exceeds requirements.
- NASA's Disturbance Reduction System for 90 days (commissioning starts June 27)
- ESA discussing potential (2-3 months) mission extension if all goes well

Hitomi

(formerly ASTRO-H)

Soft X-ray Spectrometer and Soft X-ray Telescope Mirrors



CURRENT STATUS

The U.S. provided key instrument contributions to the JAXA Hitomi mission, including:

- Soft X-ray telescope mirrors (SXT-S and SXT-I)
- X-ray Calorimeter Spectrometer Insert (CSI), including Adiabatic Demagnetization Refrigerator (ADR) and ADR Controller
- Aperture Assembly
- Following successful activation of the observatory and instruments, Hitomi suffered a mission-ending spacecraft anomaly on March 26, 2016
- Prior to mission failure, the SXS demonstrated a spectral resolution of ~ 4.7 eV, significantly exceeding the pre-launch requirement
- The SXS completed several science observations, including a scientifically important observation of the Perseus Cluster

UPCOMING EVENTS:

- Finalization of JAXA mishap investigation
- PI-led team complete analysis and archiving of available data

- **Explorer Mission of Opportunity**
- **PI:** R. Kelley, Goddard Space Flight Center
- **Launch Date:** Feb 17, 2016 on JAXA H-IIA
- **Science Objectives:** Study the physics of cosmic sources via high-resolution X-ray spectroscopy. The SXS will enable a wide range of physical measurements of sources ranging from stellar coronae to clusters of galaxies.

SOFIA

Stratospheric Observatory for Infrared Astronomy



- **World's Largest Airborne Observatory**
- 2.5-meter telescope
- 80/20 Partnership between NASA and the German Aerospace Center (DLR)
- Science Center and Program Management at NASA-Ames Research Center
- Science Flight Operations at NASA-Armstrong Flight Research Center
- Four US and Two German science instruments commissioned
 - Provide imaging, spectroscopy and photometry ranging from visible to far infrared
 - Advanced science instruments under development for future operation

CURRENT STATUS:

- In prime mission operation since May 2014
- Observing status:
 - Pluto occultation data (July 2015) synergistic with New Horizons
 - Calibrated data from Horsehead nebula released in February 2016 with no proprietary restrictions
 - Cycle 4 started in February 2016
 - 7-week, 3 science instrument deployment to Christchurch, New Zealand planned from June 4 – July 25, 2016
- Second generation instruments:
 - Commissioned upGREAT, multi-pixel heterodyne spectrometer (German instrument)
 - Testing/integrating HAWC+, far infrared imager & polarimeter; 2016 commissioning (U.S. instrument)
- Two Third-generation instrument concepts selected in 2016 for six month study. Down select in August 2016.
- Implemented science community feedback and IG recommendations for improved science productivity
 - Large impact science observation program offerings
 - Increased guest investigator support by a factor of 3 (~\$10K per hour of observing)
 - Increased capacity to deploy multiple instruments
 - Increased support for future science instrumentation
- Re-competing contract for science mission operations 21

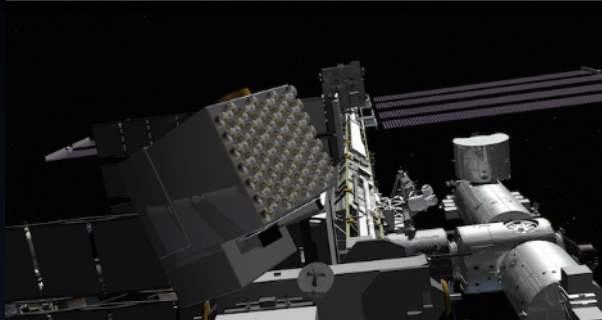
<https://www.sofia.usra.edu/>

Astrophysics Missions in Development

NICER

NASA Mission

2/2017

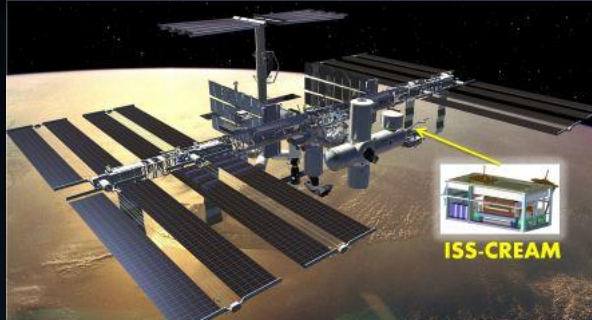


Neutron Star Interior
Composition Explorer

CREAM

NASA Mission

6/2017

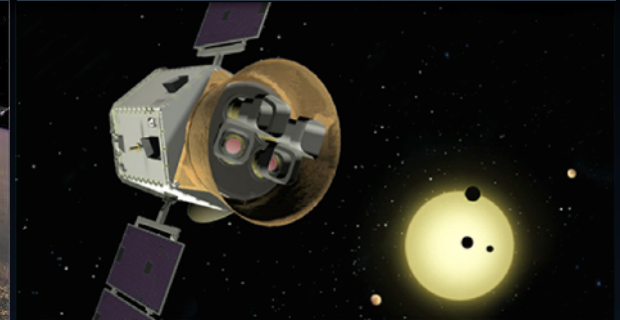


Cosmic Ray Energetics
And Mass

TESS

NASA Mission

12/ 2017

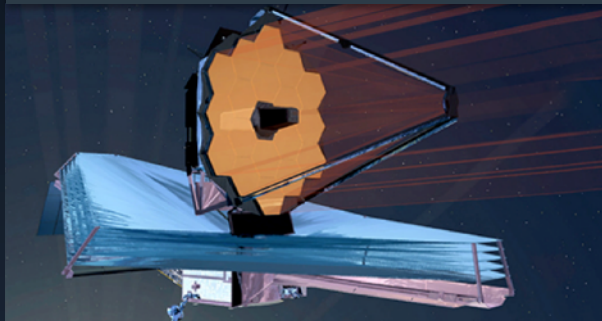


Transiting Exoplanet
Survey Satellite

Webb

NASA Mission

10/2018

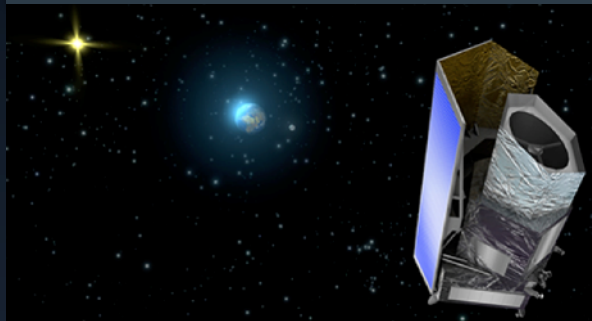


James Webb
Space Telescope

Euclid

ESA-led Mission

2020

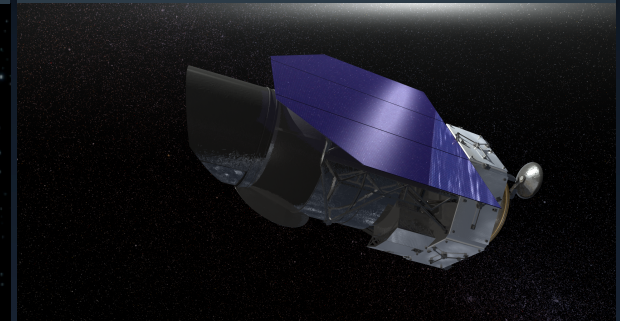


NASA is supplying the NISP
Sensor Chip System (SCS)

WFIRST

NASA Mission

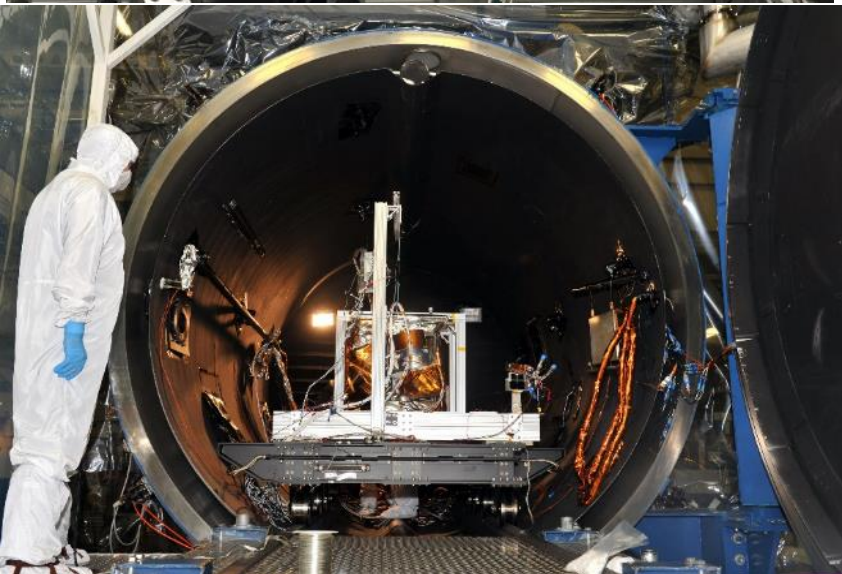
Mid 2020s



Wide-Field Infrared
Survey Telescope

NICER

Neutron star Interior Composition Explorer

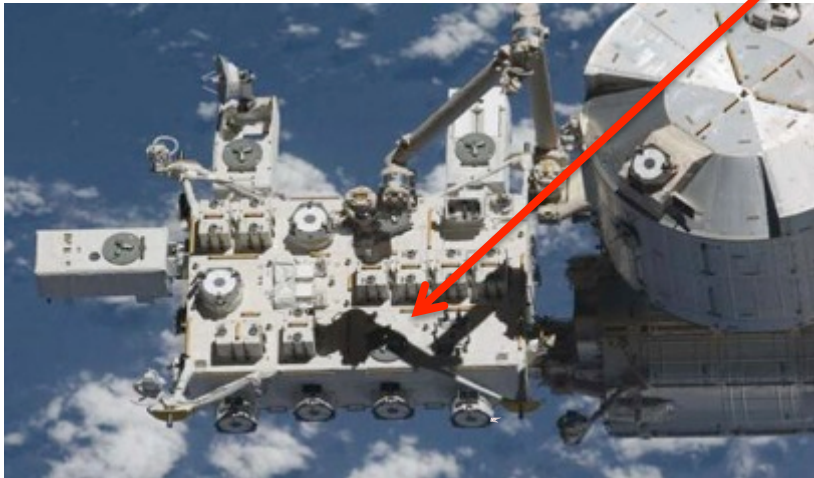
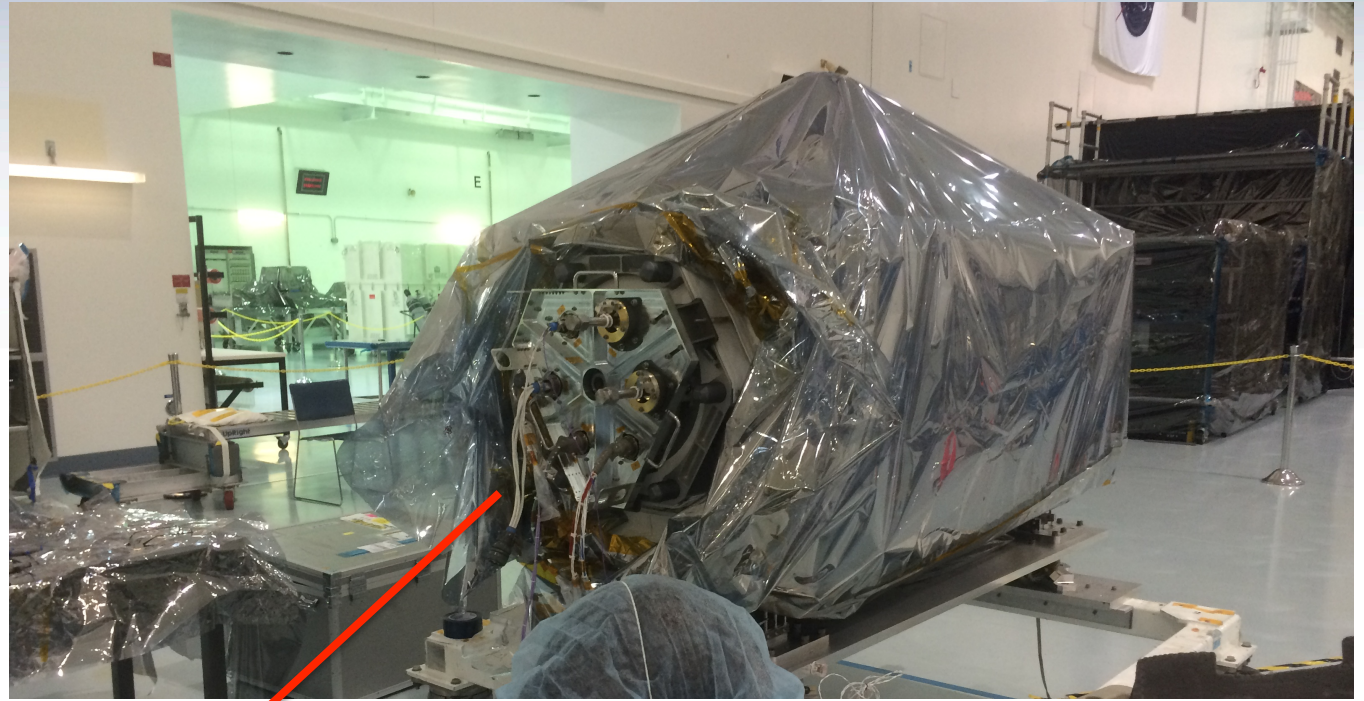


- All subsystems/sub-assemblies have completed fabrication and environmental testing ✓
- The NICER payload completed final integration and test ✓
- December 2015: Pre-environmental Review ✓
- January 2016: Start Phase D ✓
- February 2016: Start of payload environmental testing ✓
- April 2016: Completion of payload environmental testing ✓
- June 2016: Payload delivered to KSC and stored at KSC until launch ✓
- February 2017 (TBC): Launch on SpaceX-11 commercial resupply service (CRS) flight to ISS

<https://heasarc.gsfc.nasa.gov/docs/nicer/>

CREAM

Cosmic Ray Energy and Mass

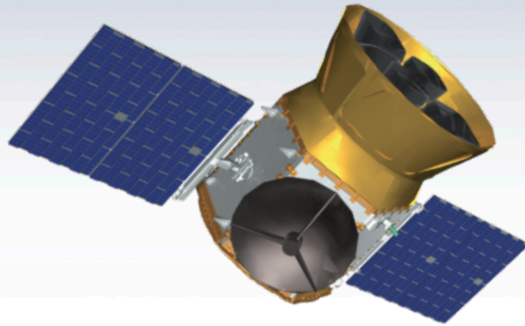


- July 2015: CREAM delivered to KSC and stored at KSC until launch ✓
- June 2017 (TBC): Launch on SpaceX-12 commercial resupply service (CRS) flight to ISS

<http://cosmicray.umd.edu/iss-cream/>

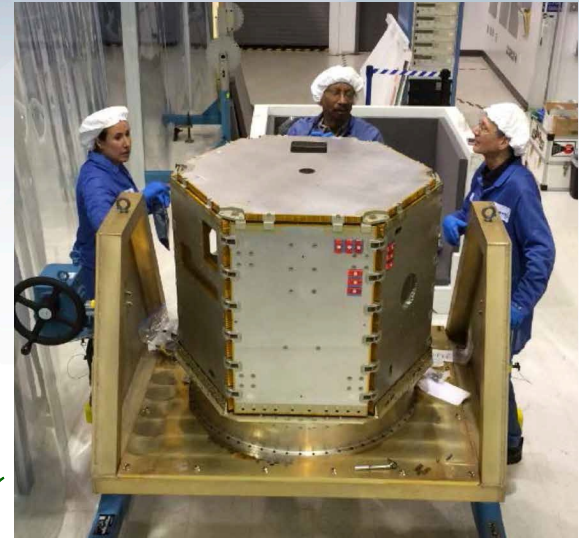
TESS

Transiting Exoplanet Survey Satellite



CURRENT STATUS:

- CDR completed Dec 7, 2015; Mission in fabrication and assembly phase ✓
- Most spacecraft bus components have been delivered and s/c is being assembled ✓
- Flight instrument build underway; first lots of flight CCDs have been produced ✓
- Flight camera optics in assembly ✓



Medium Explorer (MIDEX) Mission

PI: G. Ricker (MIT)

Mission: All-Sky photometric exoplanet mapping mission.

Science goal: Search for transiting exoplanets around the nearby, bright stars.

Instruments: Four wide field of view (24x24 degrees) CCD cameras with overlapping field of view, operating in the Visible-IR spectrum (0.6-1 micron).

Operations: NLT June 2018 launch with a 3-year prime mission including 2 years of spacecraft operations and an additional 1 year ground-based observations and analysis. High-Earth elliptical orbit (17 x 58.7 Earth radii).

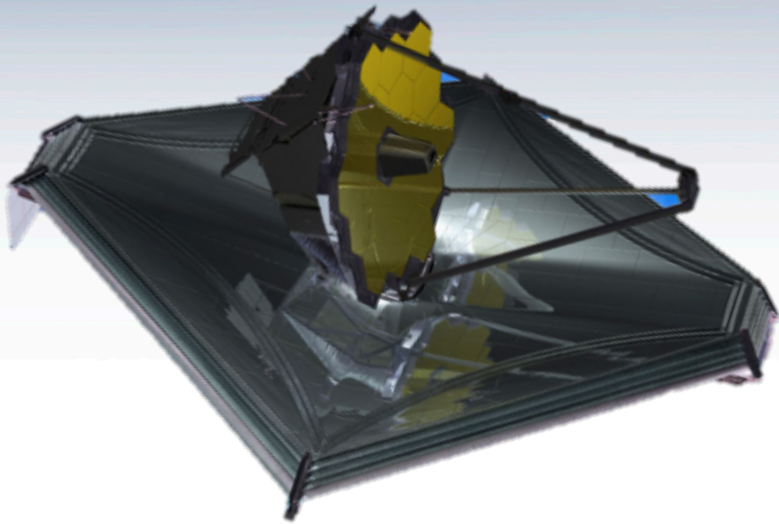
UPCOMING EVENTS:

- Spring-Fall 2016 – TESS bus integration and instrument integration ongoing
- Winter-Spring 2017 – TESS Observatory integration and test
- Spring 2017 – System Integration Review (SIR) and KDP-D
- Fall 2017 – TESS delivery to KSC launch site.
- Dec 2017 – Launch readiness date from Canaveral FL

<http://tess.gsfc.nasa.gov/>

Webb

James Webb Space Telescope



2015-2016 Accomplishments

- Telescope mirrors installed ✓
- Science instruments integrated with Telescope ✓
- MIRI cryocooler completed ✓
- Spacecraft bus powered on for first time ✓
- Completed 2nd test of Pathfinder Telescope and ground support equipment at JSC in support of 2017 test of flight hardware ✓

Large Infrared Space Observatory

Top priority of 2000 Decadal Survey

Science themes: First Light; Assembly of Galaxies; Birth of Stars and Planetary Systems; Planetary Systems and the Origins of Life

Mission: 6.5m deployable, segmented telescope at L2, passively cooled to <50K behind a large, deployable sunshield

Instruments: Near IR Camera, Near IR Spectrograph, Mid IR Instrument, Near IR Imager and Slitless Spectrograph

Operations: 2018 launch for a 5-year prime mission

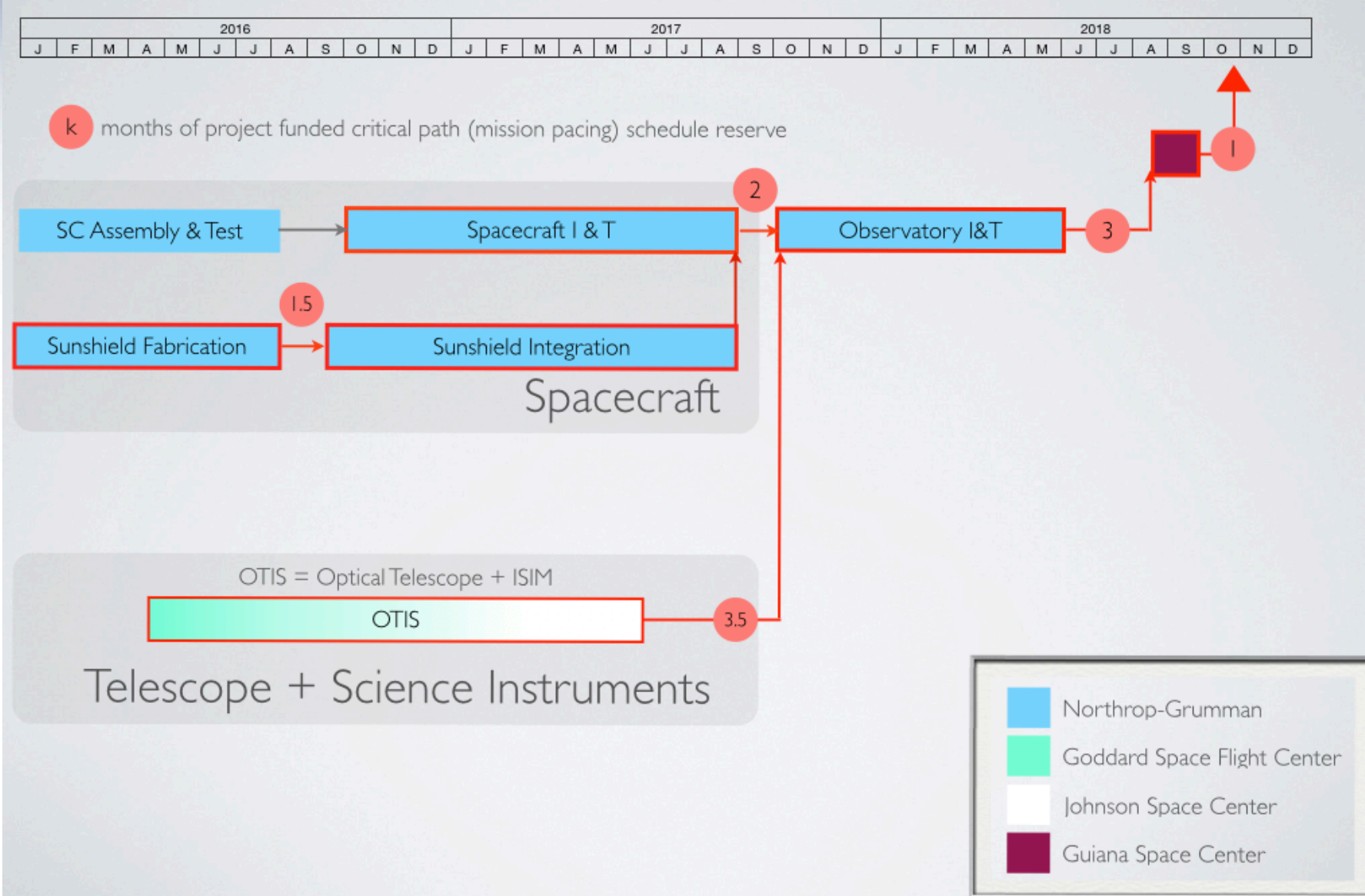
Partners: ESA, CSA

2016 Plans

- Complete ambient testing of combined Telescope and instruments
- Complete spacecraft bus
- Complete sunshield membrane fabrication
- Cryovacuum testing of combined Telescope and instruments at JSC
- Integrate Sunshield and Spacecraft

<http://www.jwst.nasa.gov/>

Webb Top Level Schedule



JWST Spacecraft



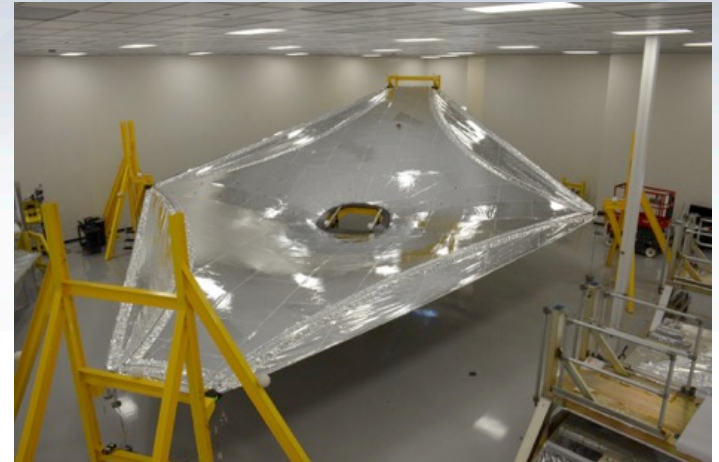
Powered-On Configuration on the -J2 Panel

Spacecraft Bus making good progress at Northrop-Grumman.
Currently in propulsion system integration stage

Webb Sunshield

Manufacturing Activity	L3	L4	L5	L2	L1
Cut Gores & Coating removal	✓	✓	✓	✓	✓
Rip stops	✓	✓	✓	✓	✓
Sub-assembly TSB seaming	✓	✓	✓	✓	✓
Assembly TSB seaming	✓	✓	✓	✓	✓
ACS off-nominal Bonding	✓	✓	✓	N/A	N/A
Bonding & Assembly	✓	✓	✓	✓	In-process
Initial Shape Test (IST)	✓	✓	✓	✓	N/A
Hole Tool (-J2 side)	✓	✓	✓	✓	
Hole Tool (+J2 side)	✓	✓	✓	✓	
Vent Holes	✓	✓	✓		
Grounding	✓	✓	In-process		
MDMS	✓	✓	In-process		
Acceptance Shape Test (AST)	✓	✓			
Epaulets & Closeout	✓	✓			
Verification	✓	✓			
Package & Ship	✓	✓			

Flight Layer 2 Membrane



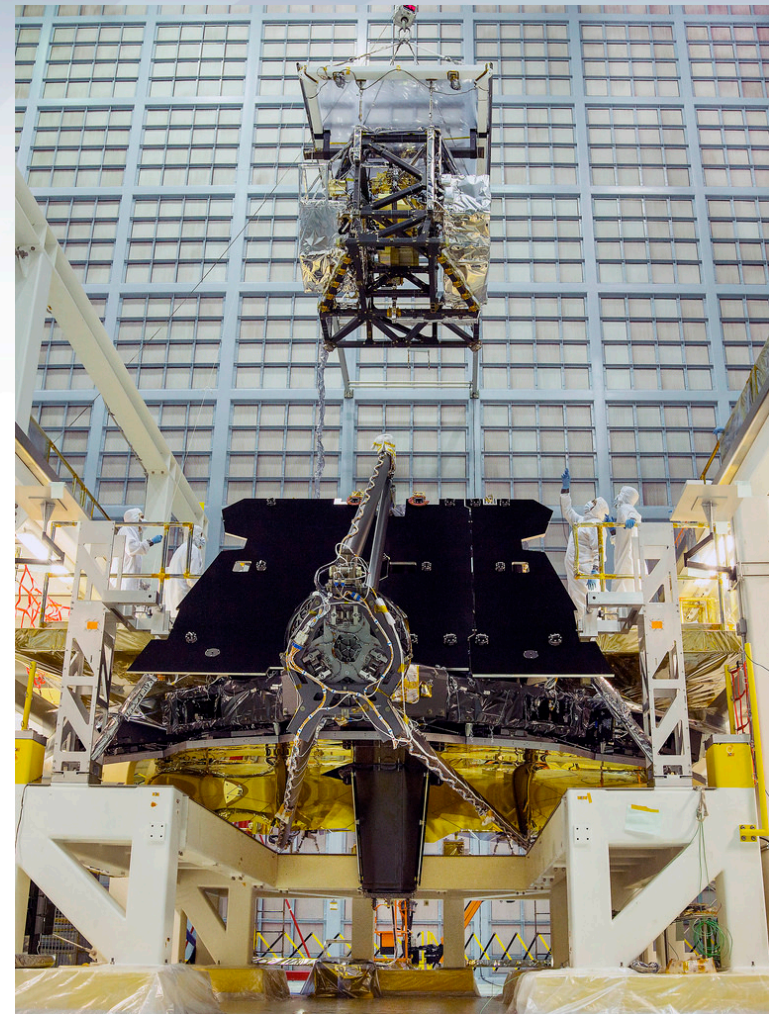
Flight Layer 1 Membrane



Webb Telescope & Instruments



Primary Mirror on a turnover fixture at GSFC



Science Instruments being installed into Telescope Backplane Support Fixture

JWST remains on track for an October 2018 launch within its replan budget guidelines₃

WFIRST

Wide-Field Infrared Survey Telescope

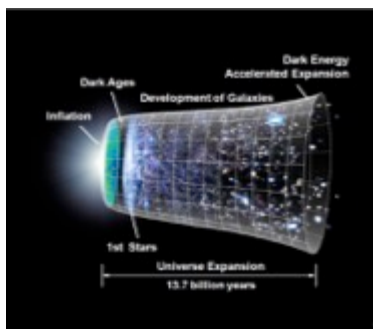
WFIRST highest ranked large space mission in 2010 Decadal Survey

- Study Dark Energy, Exoplanet Census, NIR Sky Survey

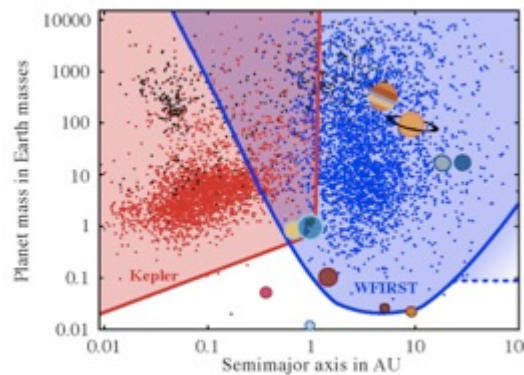
Use of 2.4m telescope enables

- Hubble quality imaging over 100x more sky
- Imaging of exoplanets with 10^{-9} contrast with a coronagraph

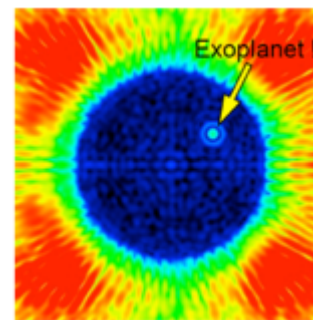
Dark Energy



Exoplanets

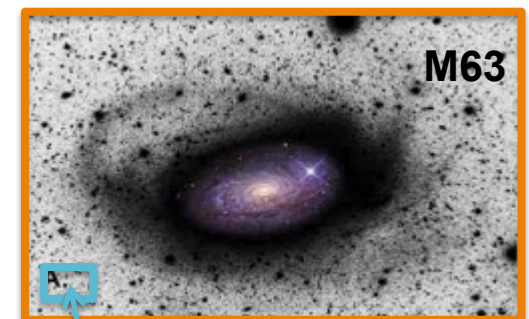


Microlensing



Coronagraph

Astrophysics



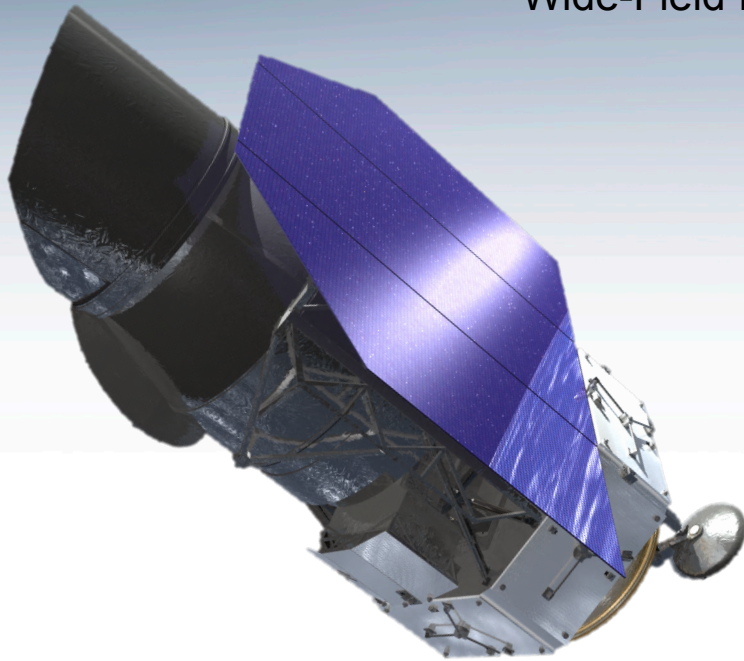
HST

WFIRST

<http://wfirst.gsfc.nasa.gov/>

WFIRST

Wide-Field Infrared Survey Telescope



CURRENT STATUS:

- Completed Mission Concept Review (MCR) held in December 2015
- Formulation Science Investigation Teams selected in December 2015; first meeting held February 2016.
- Ball and Lockheed Martin selected in February 2016 to support Wide-field Instrument Concept Studies
- Passed Key Decision Point A (KDP-A) in Feb 2016
 - Official start of formulation phase
 - Successful KDP-A held February 17, 2016
 - Established management agreement for total mission cost to govern formulation trades
 - Next major milestone is acquisition strategy meeting (ASM) in July 2016
- On track for TRL-6 of new technologies in 2017
- Working toward System Requirements Review (SRR) in June 2017 and KDP-B in October 2017
- FY17 budget request matches FY16 appropriation of \$90M. In-guide budget supports launch in mid-2020s.

Wide-Field Infrared Survey Telescope

Top priority of 2010 Decadal Survey

Science themes: Dark Energy, Exoplanets, Large Area Near Infrared Surveys

Mission: 2.4m widefield telescope at L2; using existing hardware, images 0.28deg^2 at $0.8\text{-}2\mu\text{m}$

Instruments (design reference mission): Wide Field Instrument (camera plus IFU), Coronagraph Instrument (imaging/IFS)

Phase: Currently in Formulation (Phase A)

WFIRST has begun Formulation

<http://wfirst.gsfc.nasa.gov/>



NASA Astrophysics

Budget Update

FY16 Appropriation

Outyears are notional planning from FY16 President's budget request

(\$M)	2014	2015	2016	2017	2018	2019	2020
Astrophysics*	\$678	\$685	\$731	\$707	\$750	\$986	\$1118
JWST	\$658	\$645	\$620	\$569	\$535	\$305	\$198
Total	\$1336	\$1330	\$1351	\$1273	\$1285	\$1291	\$1316

* Excludes "SMD STEM Activities" in all years.

- Provides \$90M for WFIRST and directs NASA to start Formulation.
- Provides full funding (\$85M) for SOFIA operations and places SOFIA into the 2018 Astrophysics Senior Review.
- Provides full funding (\$98M) for continued Hubble operations.
- Provides \$37M for SMD STEM education activities.
- Requires reduction of \$36M in rest of Astrophysics portfolio.

(\$M)	FY16 Request	FY16 Approps	Delta
JWST	\$620	\$620	--
WFIRST	\$14	\$90	+\$76
SOFIA	\$85	\$85	--
Hubble	\$97	\$98	+\$1
Rest of Astrophysics*	\$493	\$457	-\$36 (-7%)
Total	\$1309	\$1351	+\$42

* Excludes "SMD STEM Activities."

FY16 Appropriation

- Addressing the \$36M reduction across the rest of Astrophysics

Project	\$ FY16	Impact
Explorers Futures	\$11M	Two month delay in development of future Explorers missions
TESS	\$11M	Use of reserves not needed by the TESS project in FY16, with payback to the TESS project in FY17 and FY18 (rephasing of reserves)
ASTRO-H	\$7M	Use of reserves held by the ASTRO-H project in case of problems in I&T or a launch delay; not needed by ASTRO-H project because ASTRO-H launched on time
R&A	\$3M	One year reduction; fewer selections spread over FY16-FY17
Spitzer	\$3M	Additional support from SMD makes up for reduction

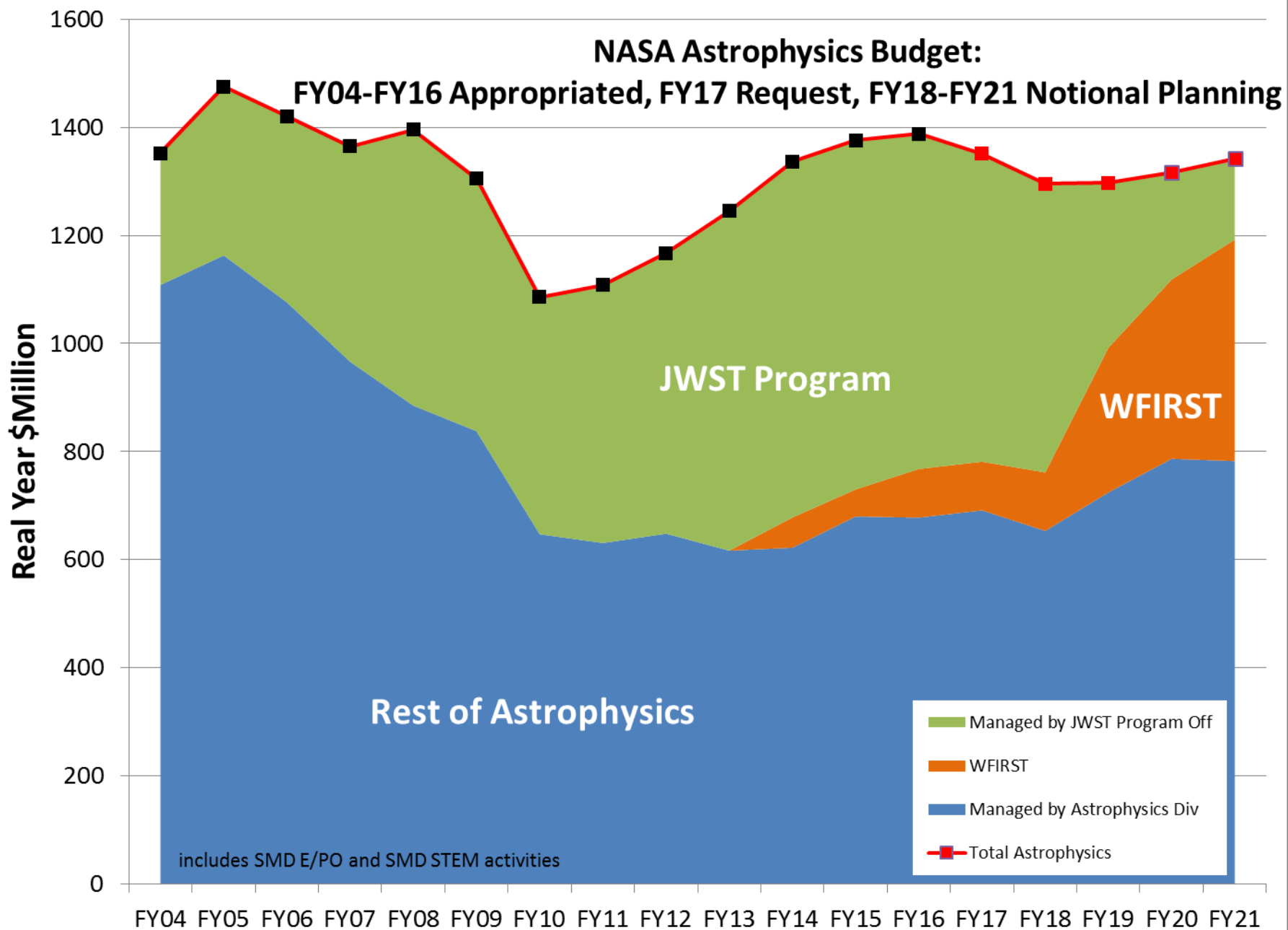
FY17 Budget Request

Outyears are notional planning from FY17 budget request

(\$M)	2015	2016	2017	2018	2019	2020	2021
Astrophysics*	\$685	\$731	\$757	\$737	\$967	\$1094	\$1168
JWST	\$645	\$620	\$569	\$534	\$305	\$197	\$150
Total*	\$1330	\$1351	\$1326	\$1271	\$1272	\$1291	\$1318

* Excludes “SMD STEM Activities” in all years.

- This budget request is an excellent budget request for NASA Astrophysics (\$1,326M excluding STEM).
- It compares well with the FY16 Appropriation (\$1,351M excluding STEM) and significantly exceeds the FY17 notional runout in the President’s FY16 request for NASA Astrophysics including JWST (\$1,276M excluding STEM).
- This budget request and the notional runout allows WFIRST to be executed without additional funding.
- This budget request and the notional runout support other Decadal Survey priorities.
 - Continued Explorer AOs at the cadence of 4 per decade.
 - Partnerships on ESA’s Athena X-ray observatory and L3 gravitational wave observatory.
 - Precursor exoplanet science and technology including Large Binocular Telescope Interferometer, Extreme Precision Doppler Spectrometer, and WFIRST Coronagraph.
 - Retains prior growth in R&A and suborbital programs.
- Senior Review funding is inadequate to continue all currently operating missions in FY17-FY18 without reductions in mission and GO funding.



FY17 Appropriations

- Both the House and the Senate appropriation subcommittees for NASA have marked up the President's budget request for NASA.
- Neither chamber has had a full vote on the NASA appropriation.
- Both chambers made changes to the President's budget request for NASA. The differences must be resolved before the FY17 NASA appropriation can be signed into law.

(\$M)	FY17 Request	Senate Mark	Senate Delta	House Mark	House Delta
Total Astrophysics	1350.9	1376.4	+25.5	1362.3	+11.4
JWST	569.4	569.4		569.4	
Hubble	97.3	98.3	+1.0		
SOFIA	83.8	83.8		85.2	+1.4
WFIRST	90.0	120.0	+30.0		
Mirror Tech		5.0	+5.0		
Starshade Tech				10.0	+10.0
STEM	25.0	42.0	+17.0		
Rest of Astrophysics		457.9	-27.5	697.7	0



NASA Astrophysics

Planning for the 2020 Decadal Survey

Responding to the 2010 Decadal Survey

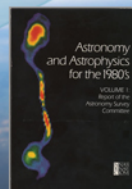
Prioritized Recommendation	NASA plans
LARGE ACTIVITIES	
WFIRST	In Phase A, launch in mid-2020s
Explorers	Executing 4 AOs per decade
LISA	Partnering on ESA's space-based gravitational wave observatory
IXO	Partnering on ESA's Athena x-ray observatory
MEDIUM ACTIVITIES	
Exoplanet technology	WFIRST coronagraph, Starshade and coronagraph technology development
Inflation Probe technology	3 balloon-borne technology experiments
SMALL ACTIVITIES	
R&A augmentations	R&A up 20% since FY10
Mid-TRL technology	Initiated Strategic Astrophysics Technology program
Suborbital missions	Initiated ultra long duration balloon capability

ASTROPHYSICS

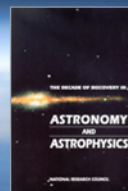
Decadal Survey Missions



1972
Decadal Survey
Hubble



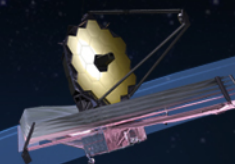
1982
Decadal Survey
Chandra



1991
Decadal Survey
Spitzer, SOFIA



2001
Decadal Survey
JWST



2010
Decadal Survey
WFIRST



Preparing for the 2020 Astrophysics Decadal Survey

- NASA has begun to study large mission concepts as input to the 2020 Decadal Survey
 - A well informed Decadal Survey makes better recommendations
- NASA has appointed Science and Technology Development Teams and initiated four large mission concept studies
 - X-ray Surveyor
 - Far Infrared Surveyor
 - Large Ultraviolet/Optical/Infrared Surveyor
 - Habitable Exoplanet Imaging Mission
- Science and Technology Definition Teams have a significant role and responsibility
 - Develop science case
 - Flow science case into mission parameters
 - Vet technology gap list
 - Direct trades of science vs cost/capability
- NASA is also planning to issue a call for medium-size mission concept studies (Astrophysics Probes)

<http://science.nasa.gov/astrophysics/2020-decadal-survey-planning/>

Preparing for the 2020 Decadal Survey

Large Mission Concepts

NASA has assembled Science and Technology Definition Teams (STDTs) for each of the four large mission candidates to enable Mission Concept Studies as input to the 2020 Decadal Survey.

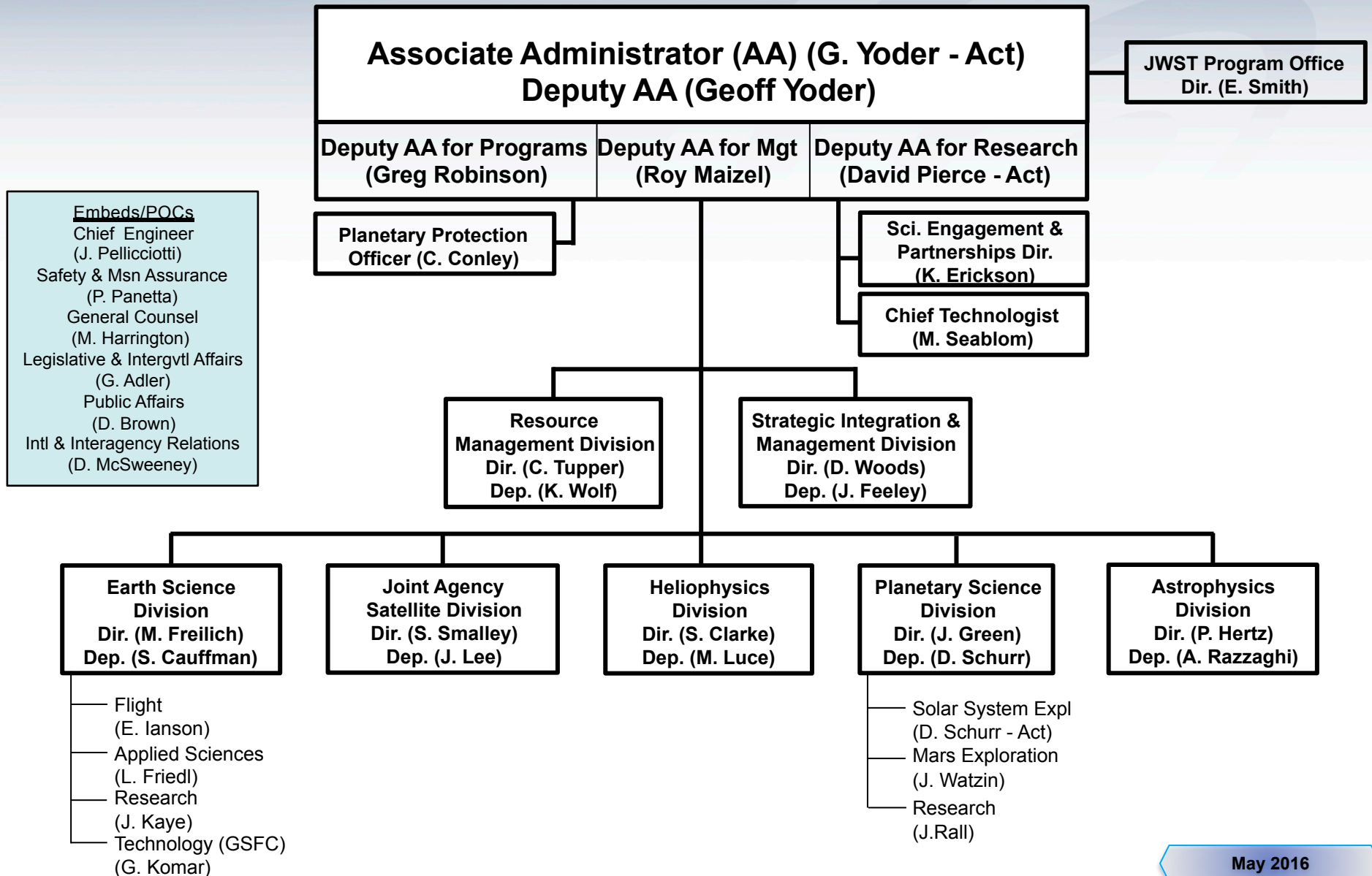
	Community STDT Chairs	Center Study Scientist	Study Lead Center	HQ Program Scientist
Far IR Surveyor asd.gsfc.nasa.gov/firs	Asantha Cooray Margaret Meixner	David Leisawitz	GSFC	Kartik Sheth
Habitable Exoplanet Imaging Mission www.jpl.nasa.gov/habex	Scott Gaudi Sara Seager	Bertrand Mennesson	JPL	Martin Still
Large UV/Optical/ IR Surveyor asd.gsfc.nasa.gov/luvoir	Debra Fischer Bradley Peterson	Aki Roberge	GSFC	Mario Perez
X-ray Surveyor wwwastro.msfc.nasa.gov/xrs	Feryal Ozel Alexey Vikhlinin	Jessica Gaskin	MSFC	Dan Evans



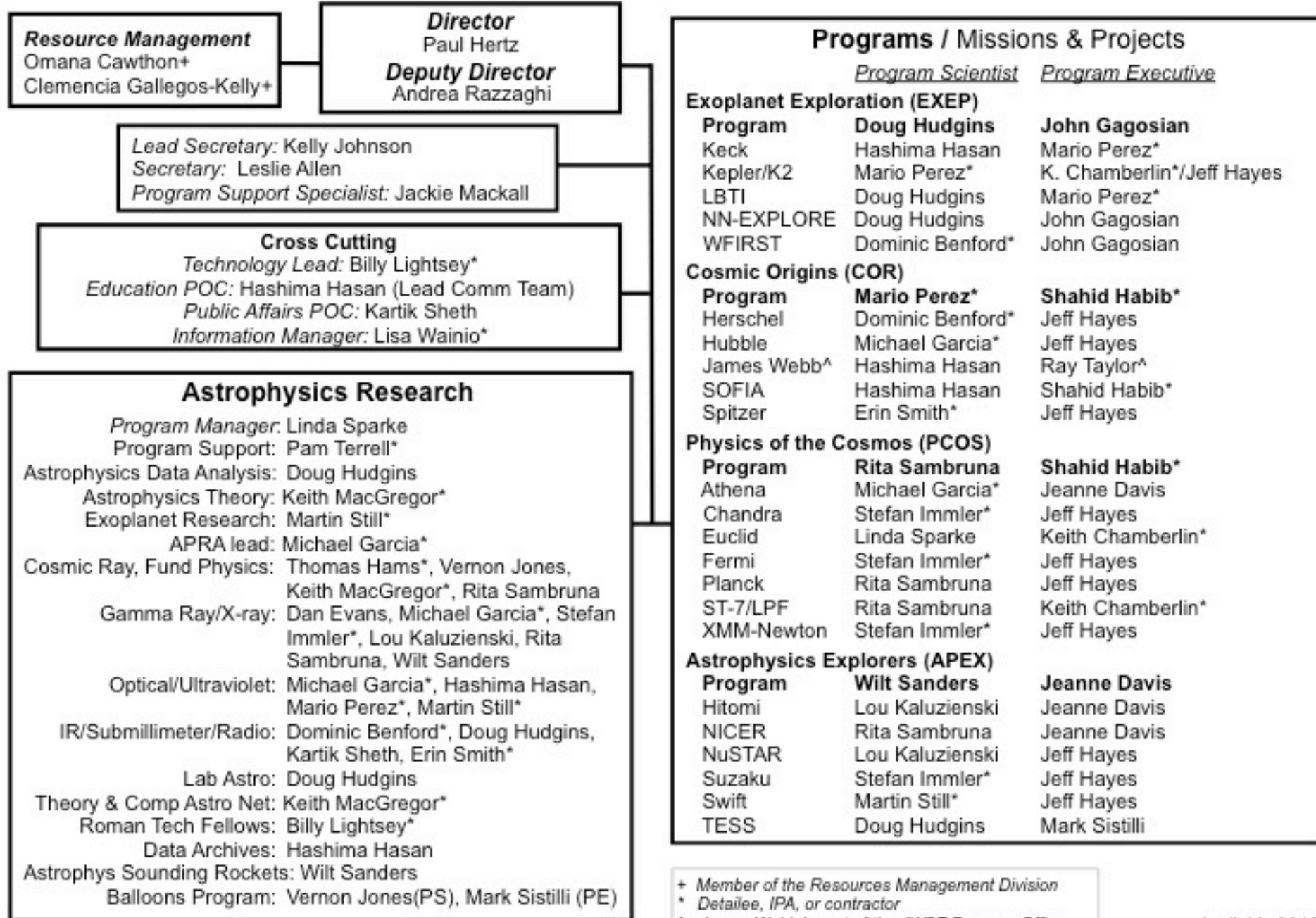


BACKUP

SMD Organization



Astrophysics Division, NASA Science Mission Directorate



SMD Education Cooperative Agreements dedicated to astrophysics

Universe of Learning (PI: Denise Smith, STScl; co-I institutions: CXC/SAO, IPAC/JPL, ExEP/JPL, Sonoma State U.; Evaluation: Goodman Research Group, Cornerstone Evaluation Associates.)

- Combines science and technology from across NASA Astrophysics with proven education infrastructure to address audience needs and SMD education objectives.
- Program Status: Start-Up Phase Underway
Year 1 funded effective 3/21/16; full team kick-off in June; Needs assessments, literature reviews, evaluation plan in progress; User benchmarking of website infrastructure initiating in May; Definition of collaborations with other CAN awardees in progress.

SOFIA Airborne Astronomy Ambassadors (PI: Dana Backman; Evaluation: WestEd)

- Scheduled Cycle 4 cohort of 22 educators for SOFIA flights between August 2016 and January 2017.
- Met with Santa Clara County (N. California) school district science coordinators for assessment of needs, aimed at eventual selection of Cycle 5 (2017) teacher cohort and baseline measurements of student performance; Scheduled meetings with Los Angeles county school officials for assessment of needs.

Girl Scouts: Reaching for the Stars (PI: Edna DeVore, SETI)

- Held two Space Science Badge design workshops.
- Drafted Badges for Daisies, Brownies, and Junior Girl Scouts (grades K-5).
- Collaborated with the GS Volunteer Tool Kit team to develop online materials for leaders.
- Supported Bridging Day for 6,500 Junior Girl Scouts at Golden Gate Bridge, San Francisco.
- Held 3-day Volunteer Leader Astronomy Camp at University of Arizona.
- Planning Girl Scout Destinations program for solar eclipse in 2017.